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IN THE UNITED STATES PATENT & TRADEMARK OFFICE

IN RE APPLICATION OF :
YUUSUKE SATO, ET AL. : EXAMINER: LEWIS, BEN
SERIAL NO: 10/810,715 :
FILED: MARCH 29, 2004 : GROUP ART UNIT: 1795
FOR: FUEL CELL SYSTEM :
.

DECLARATION UNDER 37 C.F.R. §1.132

ASSISTANT COMMISSIONER FOR PATENTS
WASHINGTON, D.C. 20231

SIR:

I, Yuusuke Sato, state that:

1. I have a master's degree from the University of Tokyo, which I received in 1987.
2. I have been employed by Toshiba for 22 years as a researcher in the field of chemical engineering related to chemical vapor deposition and fuel cell system development.
3. I understand the English language or, at least, that the contents of the Declaration were made clear to me prior to executing the same.
4. I am familiar with the above-identified application and know that the current claims, illustrated by Claim 1, define a fuel cell system comprising: a fuel tank storing a fuel comprising dimethyl ether, water, 5-10 wt% of methanol, the mixing ratio of dimethyl ether and water is in a range of 1:3 to 1:4; a vaporizer configured to vaporize the fuel; a reformer configured to reform the vaporized fuel into a hydrogen rich gas; a CO gas removal apparatus configured to remove CO gas in the hydrogen rich gas; and a fuel cell unit configured to generate electricity by electrochemical reaction of the hydrogen rich gas and oxygen.

5. I understand that the U.S. Patent Office has continued to reject the claims of this application as being obvious in view of the combination of U.S. 2002/0182460 (Okamoto), U.S. 6,777,116 (Muller) and U.S. 2004/0110046 (Pan).

6. First and significantly, both Okamoto's fuel cell and Pan's fuel cell include two fuel tanks, one for water and one for methanol. Specifically see FIG. 1 of Okamoto features 1 and 2 and FIG 1A of Pan features 102 and 110. In Claim 1 of this application, a single fuel tank contains water, methanol and DME and is different.

7. Further, special considerations had to be made and careful study of the problem with having a single fuel tank with DME, water and methanol. As both Okamoto and Pan teach keeping these fuel components separately, I find no guidance as to how to achieve the careful balance of fuel dissolution and energy density per unit are of the fuel.

8. I have previously submitted data demonstrating that the concentration of methanol at 5-10 wt% is better than methanol concentrations less than 5wt% and greater than 10% for both dissolution of the fuel components and the energy density.

9. I understand that the Examiner has not found that this previous submission demonstrated results that were unexpected. I disagree.

10. To the importance of the claimed concentration range of 5-10 wt% of MeOH.

11. I submit the calculation result of "S/C ratio" of the present invention and Pan's disclosure, based on the data represented in the declaration submitted on October 30, 2009.

12. **<Information about S/C ratio>**

Referring to the Japanese Patent Application Laid-Open H10-144335 (specifically, o paragraphs [0003]-[0004]), attached.

The supply ratio of the source gas and the steam to the reformer can be expressed by the numerical value of the steam-to-carbon ratio (hereinafter called as "S/C ratio"). The S/C

ratio increases when the relatively larger amount of steam is supplied. The S/C ratio decreases when the relatively larger amount of the source gas is supplied.

It is preferable that the S/C ratio is kept to be as small as possible in the RHFC system because it makes it easy to take out the surplus heat and use the surplus heat for other purposes. However, if the S/C ratio is too low, carbon would be deposited onto the catalytic surface of the reformer and thus, the catalyst surface could be poisoned. Accordingly, the functions of the catalyst could not be properly demonstrated.

The theoretical minimum value could be 2.0. Also, the value of S/C ratio may be 3.0 to prevent the poisoning of the catalyst.

<Calculation method of the S/C ratio >

The chemical symbol for DME is "CH₃-O-CH₃" and therefore 1 mol of DME gives 2 mole of Carbon.

The chemical symbol for MeOH is "CH₃OH" and therefore 1 mol of MeOH gives 1 mole of Carbon.

Therefore, the S/C ratio is calculated by the following formula:

S/C ratio = (number of moles of H₂O)/[(number of moles of DME × 2)+(number of moles of MeOH × 1)]

13. In the claimed invention.

(A) In the case that the methanol concentration of the claimed fuel is 5wt%

The number of moles for H₂O, MeOH and DME contained in 1mL of MeOH solution is as follows:

$$\text{H}_2\text{O}=0.052\text{mol}$$

$$\text{MeOH}=0.0015\text{mol}$$

$$\text{DME}=0.013\text{mol}$$

$$\text{Therefore S/C} = 0.052\text{mol} / (0.013\text{mol} \times 2 + 0.0015\text{mol}) = 1.89$$

(B) In the case that the methanol concentration of the claimed fuel is 10wt%

The number of moles for H₂O, MeOH and DME contained in 1mL of MeOH solution is as follows:

$$\text{H}_2\text{O}=0.049\text{mol}$$

$$\text{MeOH}=0.0031\text{mol}$$

$$\text{DME}=0.017\text{mol}$$

$$\text{Therefore, S/C} = 0.049\text{mol} / (0.017\text{mol} \times 2 + 0.0031\text{mol}) = 1.32$$

Therefore,

$$\text{H}_2\text{O : DME+MeOH(5\%)} \rightarrow \text{S/C ratio} = 1.89$$

$$\text{H}_2\text{O : DME+MeOH(10\%)} \rightarrow \text{S/C ratio} = 1.32$$

The S/C ratio of the claimed invention would be 1.32-1.89.

14. Pan's disclosure

Pan is described by "weight %".

In order to calculate "S/C ratio", I converted the values of Pan's disclosure by using data described in the attached Documents:

Document 1: The Chemical Society of Japan "The Chemical Handbook: Basic Edition; Revised 5th Edition" (Table 6.22 describes specific densities of "MeOH/H₂O at 20 °C)

Document 2: http://www.methanex.com/products/documents/TISH_japanese.pdf
p6 (Document 2 describes conversion results of weight% MeOH- mol% MeOH- Volume% MeOH)

By using data of documents 1 and 2, the numbers of moles of Pan's disclosure are calculated as follows:

MeOH(5%) → 2.87mol%, specific gravity: 0.99 g/mL

MeOH(10%) → 5.88mol%, specific gravity: 0.98 g/mL

S/C ratio (MeOH (5%)) = (100mol - 2.87mol) / 2.87mol = 33.8

S/C ratio (MeOH (10%)) = (100mol - 5.88mol) / 5.88mol = 16.0

Therefore, S/C ratio of Pan's invention would be 16.0-33.8.

15. What does this mean? The methanol range between the claimed fuel and Pan's fuel is seemingly similar because both of claimed fuel and Pan's fuel disclose 5-10% of methanol. However, as understood from the above calculation results, Pan's fuel is *completely different fuel* from claimed fuel because the amounts of the S/C ratio are significantly different from each other.

16. That is to say, as shown in the paragraph (0023) of Pan's disclosure, Pan merely discloses that the fuel including 1-10 wt% (3-5 wt%) of methanol could be applicable for *only the "direct methanol fuel cell (DMFC) type."* There is no suggestion or teaching of Pan's fuel to be applicable to the Reformed type fuel cell (RHFC).

17. While I understand that the Examiner contends that if the fuel cell is to be used in an application that requires high power output, the optimal range of fuel concentration may become 5-10% by weight. However, applicant consider that Pan could not be incorporated to the fuel system of Okamoto because with regard to fuel efficiency, the principle of the DMFC as disclosed in Pan and the principle of RHFC as disclosed in claimed system are *completely different*.

18. If Pan's fuel is applied to the claimed system, S/C ratio of the fuel becomes dramatically higher than the claimed S/C ratio (more than one digit larger than claimed value) and thus, the fuel efficiency of the claimed fuel system would be significantly low. As a result, the system having a high efficiency for reforming fuel to hydrogen rich gas and a high efficiency for generating electricity with a small and simple structure (see page 2, line 17, of the present specification) could not be achieved.

19. Therefore, I consider that Pan's disclosure could not be incorporated into the fuel cell system of Okamoto as modified by Muller et al.

20. As explained in my previous Declaration, the concentration between 5 and 10 wt% was something that required careful study so that the dissolution of the components could be maintained, i.e., methanol separates from DME/water, which I believe is why Okamoto and Pan teach to keep them separate, only mixing through pumps when needed in the reactor. This was shown in the Declaration to be at about 5 % methanol. However, this is a fuel cell and therefore another important consideration in the type of fuel cell contained in the claims when being supplied from a single tank containing DME, water and methanol is the energy generated by that fuel in the cell. As described in my previous Declaration, if methanol is added in an amount greater than 10wt%, the energy density for each unit area of the fuel is decreased.

21. That this careful balance of a fuel contained supplied by a single tank was achieved at the specific concentrations and ratios as defined in the claims was achieved was not expected from what is taught by Okamoto, Pan and Muller. Indeed, I don't see how that could have been expected when as discussed before and above, the types of fuels and the manner in which they are contained and supplied to the reactor are completely different from what is defined in the claims of this application.

22. The undersigned petitioner declares further that all statements made herein of his own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of this application or any patent issuing thereon.

Guadalupe Soto
Signature

May 11, 2009
Date

表 6.20 有機液体混合物の密度 ρ (つづき)

| 溶 被 | | ϑ °C | 組成範囲 c^* (質量%) | 測定 点数 | $\rho / \text{g cm}^{-3} = \alpha c^4 + \beta c^3 + \gamma c^2 + \delta c + \epsilon$, あてはめの精度 σ | | | | | |
|-------|---------|-------------------|---------------------|------------|--|-------------------|--------------------|--------------------|------------|--------------------|
| 成 分 1 | 成 分 2 | | | | $\alpha / 10^{-8}$ | $\beta / 10^{-8}$ | $\gamma / 10^{-6}$ | $\delta / 10^{-2}$ | ϵ | $\sigma / 10^{-4}$ |
| ベンゼン | ビリジン | 25 | 0~100 | 6 | — | -0.0148239 | 0.259987 | -0.115556 | 0.978057 | 4.792 |
| | ヘキサン | 〃 | 0~100* | 9 | -0.0216075 | 0.59172 | 0.138124 | 0.655007 | 4.102 | |
| | メタノール | 25 | 0~100* | 9 | -0.0215075 | 0.591720 | 0.138124 | 0.655007 | 4.102 | |
| | アセトン | 25 | 0~100* | 8 | 0.0148009 | -0.0495734 | 0.313593 | 4945.90 | 0.785019 | 1.102 |
| | イソブチルアル | 25.05 | 0~100* | 8 | - | - | - | - | - | - |
| | コール | — | — | — | -0.0364273 | -0.00609388 | 0.798111 | 0.991 | — | — |
| | 1-ブロノール | 25 | 0~100 | 5 | — | - | - | - | - | - |
| ベンゼン | 〃 | 〃 | 8 | -0.0142555 | 0.0242377 | -0.0895703 | -0.0135588 | 0.800381 | 0.451 | |
| | ホルムアミド | 〃 | 0~100* | 9 | 0.0156568 | -0.0356576 | 0.339296 | -0.100994 | 0.873662 | 0.662 |

*1 組成 c は別記しない限り成分 1 についての質量 % である。a: c は成分 1 のモル %, b: c は成分 1 のモル分率。

本表のデータは“化学便覧 基礎編 改訂3版”，丸善 (1984) の密度データ (表 6.21, CD-ROM 参照) に四次以下の多项式をあてはめた結果である。一部適合性の悪いデータもそのまま記してある。

表 6.21 有機液体混合物の密度 ρ \Rightarrow (CD-ROM)表 6.22 メタノール/水の密度 ρ (20°C)

| 質量% | $\rho / \text{g cm}^{-3}$ |
|-----|---------------------------|-----|---------------------------|-----|---------------------------|-----|---------------------------|-----|---------------------------|-----|---------------------------|
| 1 | 0.9965 | 18 | 0.9696 | 36 | 0.9146 | 54 | 0.9073 | 72 | 0.8665 | 90 | 0.8202 |
| 2 | 0.9948 | 20 | 0.9666 | 38 | 0.9381 | 56 | 0.9032 | 74 | 0.8616 | 92 | 0.8145 |
| 4 | 0.9914 | 22 | 0.9636 | 40 | 0.9345 | 58 | 0.8988 | 76 | 0.8567 | 94 | 0.8090 |
| 6 | 0.9880 | 24 | 0.9607 | 42 | 0.9309 | 60 | 0.8946 | 78 | 0.8518 | 96 | 0.8032 |
| 8 | 0.9847 | 26 | 0.9576 | 44 | 0.9272 | 62 | 0.8902 | 80 | 0.8469 | 98 | 0.7976 |
| 10 | 0.9815 | 28 | 0.9546 | 46 | 0.9234 | 64 | 0.8856 | 82 | 0.8420 | — | — |
| 12 | 0.9784 | 30 | 0.9515 | 48 | 0.9196 | 66 | 0.8811 | 84 | 0.8366 | — | — |
| 14 | 0.9754 | 32 | 0.9483 | 50 | 0.9156 | 68 | 0.8763 | 86 | 0.8314 | — | — |
| 16 | 0.9725 | 34 | 0.9450 | 52 | 0.9114 | 70 | 0.8715 | 88 | 0.8258 | — | — |

[*International Critical Table, vol. III, McGraw-Hill (1928), p.115]

表 6.23 エタノール/水の密度 ρ (25°C)

| 質量% | $\rho / \text{g cm}^{-3}$ |
|-----|---------------------------|-----|---------------------------|-----|---------------------------|-----|---------------------------|-----|---------------------------|-----|---------------------------|
| 1 | 0.9952 | 18 | 0.9692 | 36 | 0.9395 | 54 | 0.9008 | 72 | 0.8586 | 90 | 0.8136 |
| 2 | 0.9934 | 20 | 0.9664 | 38 | 0.9356 | 56 | 0.8962 | 74 | 0.8538 | 92 | 0.8082 |
| 4 | 0.9898 | 22 | 0.9635 | 40 | 0.9315 | 58 | 0.8916 | 76 | 0.8489 | 94 | 0.8027 |
| 6 | 0.9866 | 24 | 0.9605 | 42 | 0.9273 | 60 | 0.8870 | 78 | 0.8440 | 96 | 0.7971 |
| 8 | 0.9835 | 26 | 0.9574 | 44 | 0.9230 | 62 | 0.8823 | 80 | 0.8391 | 98 | 0.7912 |
| 10 | 0.9804 | 28 | 0.9541 | 46 | 0.9187 | 64 | 0.8776 | 82 | 0.8342 | — | — |
| 12 | 0.9775 | 30 | 0.9507 | 48 | 0.9143 | 66 | 0.8729 | 84 | 0.8291 | — | — |
| 14 | 0.9747 | 32 | 0.9471 | 50 | 0.9099 | 68 | 0.8682 | 86 | 0.8241 | — | — |
| 16 | 0.9720 | 34 | 0.9434 | 52 | 0.9053 | 70 | 0.8654 | 88 | 0.8189 | — | — |

[*International Critical Table, vol. III, McGraw-Hill (1928), p.115]

表 6.24 エタノール/水の密度 ρ (30°C)

| 質量% | $\rho / \text{g cm}^{-3}$ |
|-----|---------------------------|-----|---------------------------|-----|---------------------------|-----|---------------------------|-----|---------------------------|-----|---------------------------|
| 1 | 0.9938 | 18 | 0.9670 | 36 | 0.9359 | 54 | 0.8967 | 72 | 0.8543 | 90 | 0.8092 |
| 2 | 0.9919 | 20 | 0.9640 | 38 | 0.9319 | 56 | 0.8921 | 74 | 0.8494 | 92 | 0.8038 |
| 4 | 0.9884 | 22 | 0.9609 | 40 | 0.9277 | 58 | 0.8874 | 76 | 0.8446 | 94 | 0.7984 |
| 6 | 0.9851 | 24 | 0.9577 | 42 | 0.9234 | 60 | 0.8828 | 78 | 0.8397 | 96 | 0.7927 |
| 8 | 0.9819 | 26 | 0.9544 | 44 | 0.9191 | 62 | 0.8781 | 80 | 0.8347 | 98 | 0.7868 |
| 10 | 0.9788 | 28 | 0.9510 | 46 | 0.9147 | 64 | 0.8734 | 82 | 0.8297 | — | — |
| 12 | 0.9757 | 30 | 0.9474 | 48 | 0.9103 | 66 | 0.8686 | 84 | 0.8247 | — | — |
| 14 | 0.9728 | 32 | 0.9437 | 50 | 0.9058 | 68 | 0.8639 | 86 | 0.8197 | — | — |
| 16 | 0.9699 | 34 | 0.9399 | 52 | 0.9013 | 70 | 0.8591 | 88 | 0.8145 | — | — |

[*International Critical Table, vol. III, McGraw-Hill (1928), p.116]

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【特許請求の範囲】

【請求項1】 燃料電池の負荷を測定する負荷検出工程と、測定された負荷に基づいてスチーム・カーボン比を決定する工程と、燃料電池の改質器に供給される水蒸気、原料ガスの供給量を制御して前記工程で決定されたスチーム・カーボン比にする制御工程、とを含むことを特徴とする燃料電池装置の運転方法。

【請求項2】 改質器から燃料電池に送られる改質ガスを分岐して、改質ガスの一部を改質前の原料ガスに付加するリサイクル工程を含む請求項1の燃料電池装置の運転方法。

【請求項3】 燃料電池の負荷を測定する負荷検出手段と、測定された負荷に基づいてスチーム・カーボン比を決定するスチーム・カーボン比決定手段と、スチーム・カーボン比決定手段による決定に基づいて燃料電池の改質器に供給される水蒸気、原料ガスの供給量を制御する供給量調節手段、とを含むことを特徴とする燃料電池装置。

【請求項4】 改質器から改質ガスを燃料電池に送る改質ガス通路から分岐して、改質前の原料ガスを改質器へ供給する原料ガス通路に合流する改質ガスリサイクル通路と、該リサイクル通路に介されて改質ガス通路からの分岐流量を調節する分岐流量調節手段、とを含む請求項3の燃料電池装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、原料ガス及び水蒸気を原料として発電する燃料電池装置及びその運転方法に関する。

【0002】

【従来の技術】燃料電池の運転に際して、原料ガス及び水蒸気は先ず改質器に供給され、大量の水素を包含するガス(水素リッチガス:改質ガス)に改質されてから燃料電池本体に供給される。

【0003】ここで、原料ガスと水蒸気とをどの様な割合で改質器へ供給するのかについては、スチーム・カーボン比($m:1$ 比:以下「 S/C 比」と記す)という数値で表現される。すなわち、相対的に水蒸気の量が多い場合には S/C 比が多くなり、原料ガスの割合が多くなると S/C 比が低下する。

【0004】 S/C 比が小さいと、余剰の熱量を外部に取り出して別途有効利用をし易いので、出来る限り小さいことが望ましい。しかし、 S/C 比が小さいと、改質器の触媒表面に炭素が析出した状態、所謂「触媒が被毒した状態」となり、触媒の反応促進機能が発揮されなくなってしまう。そして、 S/C 比の理論的な最小値は2.0であるが、触媒の被毒を予防するため、実際の(燃料電池の)運転では S/C 比を3.0程度としている。

【0005】

【発明が解決しようとする課題】しかし、 S/C 比を3.0程度で運転した場合には、燃料電池の負荷が低い領域では所望の発電効率(見掛けの発電効率)が得られないという問題が存在する。図5を参照して、その理由を説明する。

【0006】図5において、燃料電池装置の水蒸気発生量(スチーム発生量)は特性線a-m-nであり、燃料電池の発電量(セル発電量:kW:原燃料の必要量に比例)は特性線b-r-pであり、外部出力(kW)は特性線c-r-0、燃料電池装置の運転に必要な水蒸気量(必要スチーム量)は特性線d-m-p、発電効率は特性線e-r-0で示されている。そして、符号rで示す箇所よりも負荷率が大きい領域においては、発電効率は一定である(特性線e-rの範囲)が、符号rより負荷率が小さい領域(特性線r-0の範囲)では発電効率が低下している。

【0007】符号rと負荷率が同一な箇所mよりも負荷率が小さな領域(特性線m-nの領域)においては、運転に必要な水蒸気量(必要スチーム量)は負荷率とは無関係に一定の数値を示し、燃料電池の発電量(セル発電量)も、特性線r-pの領域においては必要スチーム量に対して一定の数値となる。そして、負荷率が小さな領域において(特性線r-pの領域)、外部出力に比例した発電量しか発電しない場合には、発生スチーム量が改質に必要なスチーム量に達成しない。そのため、セル発電量の中から、燃料電池の改質に必要な水蒸気を発生するための電力が優先的に使用される。従って、符号rより負荷率が小さい領域(特性線r-0の範囲)では、発電効率が低下するのである。

【0008】本発明は上述した従来技術の問題点に鑑みて提案されたものであり、低負荷領域においても所定の発電効率を保持することが出来る様な燃料電池装置及びその運転方法の提供を目的としている。

【0009】

【課題を解決するための手段】本発明の燃料電池装置の運転方法は、燃料電池の負荷を測定する負荷検出工程と、測定された負荷に基づいてスチーム・カーボン比(S/C 比)を決定する工程と、燃料電池の改質器に供給される水蒸気、原料ガスの供給量を制御して前記工程で決定されたスチーム・カーボン比(S/C 比)にする制御工程、とを含んでいる。

【0010】また、本発明の燃料電池装置は、燃料電池の負荷を測定する負荷検出手段と、測定された負荷に基づいてスチーム・カーボン比(S/C 比)を決定するスチーム・カーボン比決定手段(S/C 比決定手段)と、スチーム・カーボン比決定手段(S/C 比決定手段)による決定に基づいて燃料電池の改質器に供給される水蒸気、原料ガスの供給量を制御する供給量調節手段、とを含んでいる。

【0011】この様に構成された本発明によれば、負荷

或いは負荷率が大きい領域では、その旨を負荷検出手段で検出し、 S/C 比決定手段で S/C 比を大きな数値に決定する。これにより、単位燃焼当たりの水素ガス量を適正なものとし、且つ、水蒸気にに対する原料ガスの割合を小さくして被毒を予防する。一方、負荷率いは負荷率が小さい領域では、 S/C 比を小さな数値に決定する。 S/C 比が小さくなれば必要スチーム量が減少するので、 S/C 比が高い場合に比較して、負荷率が低い側でもスチーム発生量が必要スチーム量を上回り、余剰スチームが発生する。そのため、負荷率が低い領域であっても、外部に取り出すべき発電量により水蒸気を発生させる必要が無くなる。換言すれば、 S/C 比が小さくなり、必要スチーム量が減少した結果、余剰スチームが発生する臨界点、すなわち発電効率が低下する臨界点が、負荷率の小さい側へ移行したのである。

【0012】ここで、本発明の燃料電池装置の運転方法において、改質器から燃料電池に送られる改質ガスを分歧して、改質ガスの一部を改質前の原料ガスに付加するリサイクル工程を含んでいるのが好ましい。

【0013】なお、例えば特開平7-215701号公报では、改質ガスの一部を改質前の段階にリサイクルして、触媒に対する炭素析出量を減少することにより、 S/C 比を低下しても被毒を予防することが出来る技術が開示されている。

【0014】また本発明の燃料電池装置の運転装置は、改質器から改質ガスを燃料電池に送る改質ガス通路から分歧して、改質前の原料ガスを改質器へ供給する原料ガス通路に合流する改質ガスリサイクル通路と、該リサイクル通路に介装されて改質ガス通路からの分歧流量を調節する分歧流量調節手段、とを含んでいるのが好ましい。

【0015】改質されたガスは二酸化炭素 (CO_2) と水素 (H_2) を包含するが、二酸化炭素 (CO_2) は炭素析出をせず、原料炭化水素濃度の希釈剤として働き、そのため、 S/C 比を低くしても被毒の恐れが少ないものである。

【0016】【発明の実施の形態】以下、添付図面の図1-4を参照して、本発明の実施形態について説明する。なお、図において同一の部材には同一の符号を付して、重複説明を省略する。図1において、本発明の燃料電池装置は全体を符号10で示している。

【0017】燃料電池装置10には、それぞれ通路1、2、14を介して原料ガス(矢印A1)及び水蒸気(矢印A2)が供給される。ここで、原料ガスA1及び水蒸気A2の供給量、或いは供給比率(S/C 比)は、それぞれ開閉弁V2、V3の開度を制御(制御様について後述)することにより調節される。なお、燃料電池装置10には矢印A3で示す空気も供給されており、この空気A3は通路16を介して燃料電池本体(セル)24

の空気極に供給されると共に、通路18を介して改質器バーナへ供給される。

【0018】通路12、14を介して供給された原料ガスA1及び水蒸気A2は、エジェクタ20で合流して、通路21を介して改質器22へ供給される。改質器22に供給された燃料ガス CH_4 と水蒸気 H_2O は、改質器22内の反応により水素ガス H_2 を多く包含した二酸化炭素 CO_2 との混合ガス(水素リッチガス:改質ガス)となる。そして通路23を介して、燃料電池本体(セル)24の燃料極に改質ガスが供給される。

【0019】通路23からは、開閉弁V1を介装する通路27が分歧しており、この分歧通路27は、原料ガスA1の供給通路12に(エジェクタ20の上流側にて)合流している。

【0020】燃料電池本体(セル)24から排出された改質ガスは、通路25を介して改質起バーナ26に供給され、排気通路28より排出される。また、セル24で発生した直流電流は、図1において2本線で示すラインLDを介してインバータ30に送られ、インバータ30において交流に変換されて負荷に供給される(矢印LA)。

【0021】ラインLDには負荷センサ32が介装されており、その測定結果は信号伝達ラインL1を介してコントロールユニット40に送られる。このコントロールユニット40はスチーム・カーボン比決定手段に該当する部材である。コントロールユニット40には、センサ32で検出された負荷と S/C 比との関係が数式、特性図、或いはテーブル等の形態で記録された第1のメモリ52と、当該メモリ及びセンサ32からの出力信号によ

り S/C 比を求める第1の演算手段54と、 S/C 比と開閉弁V2、V3の弁開度との関係が数式、特性図、或いはテーブル等の形態で記録された第2のメモリ56と、第1の演算手段の出力と第2のメモリから開閉弁V2、V3の弁開度を決定する弁開度決定手段58、とを備えている。そして、該弁開度決定手段58の出力信号は、それぞれ信号伝達ラインL2、L3を介して、原料ガスA1の供給量を制御する開閉弁V2のアクチュエータ42と、水蒸気A2の供給量を制御する開閉弁V3のアクチュエータ43に送出されて、該弁V2、V3の弁開度を決定された S/C 比に対応する開度にせしめるのである。

【0022】なお、弁V2及びアクチュエータ42は原料ガスの供給量を制御する供給量調節手段に該当し、弁V3及びアクチュエータ43は水蒸気の供給量を制御する供給量調節手段に該当する。そして、符号L4はセル24の空気極への空気供給量を制御するための信号伝達ライン、符号L5は分歧通路27を流れるリサイクル用の改質ガスの流量を制御するための信号伝達ラインである。

【0023】次に図2及び図3をも参照して、図1で示

す実施形態の作用を説明する。ここで、 S/C 比は負荷に対応して、2種類の数値 F_1 （図3では3）、 F_2 （図3では2）のいずれかに決定されるものとする。

【0024】先ず、負荷が低下して S/C 比が3から2に低下する場合の制御を説明する。負荷センサ32により燃料電池装置10の負荷を検出する（ステップS1）。そして、検出された負荷（図示の実施例では負荷率）が所定値（ケース・バイ・ケースで定まる数値）を下回ったか否かを判断する（ステップS2）。ここで、図3において符号r、m、qで示す箇所に対応する負荷率、すなわち負荷率50%を、図示の実施形態における前記所定値とする。

【0025】検出された負荷が所定値を下回れば（ステップS2がYeS）、第1のメモリ52及び第1の演算手段54により、（それまで3であった） S/C 比が2に決定される（ステップS3）。なお、図示の実施形態においては、負荷率が低い場合（ステップS2がYeSの場合）には、触媒の被毒を防止するため、開閉弁V1を開放して改質ガスのリサイクルを行う（ステップS4）。

【0026】ステップS3において S/C 比が決定したならば（ S/C 比=2）、原料ガスA1と水蒸気A2との供給量の比率が決定された S/C 比（=2）と一致する様に、開閉弁V2、V3の開度を調節する。具体的には、第1の演算手段54の出力と、第2のメモリ56と、弁開度決定手段58により対応する弁V2、V3の開度が求め、制御信号としてラインL2、L3を介して各弁のアクチュエータ42、43に送られるのである（ステップS5、ステップS6）。

【0027】この様に S/C 比を3から2に変化させた効果については、主として図3を参照して説明する。図3において、符号x1で示す箇所は、 S/C 比=3から S/C 比=2へ移行する点を示している。 S/C 比=3の状態でスチームの余剰が無くなる前に、 S/C 比=2の状態に移行するのである。符号x2は、符号x1で示す箇所において S/C 比=3から S/C 比=2へ移行した際に、 S/C 比=2における必要スチーム量を示す箇所である。符号m2及びq2で示す箇所は、 S/C 比=2の状態でもスチームの余剰あるいは余裕が無くなると判断される点である。但し、各々の燃料電池により、スチームの余裕の判定方法が異なる。なお、「m2-q2」が余裕となる。符号Yは、前記余裕（m2-q2）が下限値となる箇所、或いは、前記余裕が無くなると判断される箇所を意味している。そして、符号Yで示す箇所より負荷が小さい領域では、余剰スチーム量（或いは余裕：m2-q2）が一定となる様に制御される。なお、上述した符号x1、x2、m2、q2等は、各燃料電池の特性により異なり、各々の燃料電池でマスバランス、熱バランスを計算する必要がある。図3において、負荷率50%の箇所で S/C 比が3から2に変化した結果、

必要スチーム量の特性線はd-q-sからd-x1-x2-q2-s2に変化する。これに伴い、スチーム発生量はa-r-pで示す特性線からa-m2-n2で示す特性線に変化し、発電量も特性線b-r-pから特性線b-y-p2に変化する。

【0028】発電効率は、図4からも分かる通り、 S/C 比が3である場合には負荷率50%程度から悪化する。これに対して、 S/C 比を2とした結果、符号y、m2、q2に対応する負荷率、負荷率30%程度、まで所定の効率（約40%）を保つことが出来る。

【0029】一方、負荷が増加して S/C 比が2から3に増加する場合は、これと概略同様な制御が行われる。すなわち、負荷（負荷率）が所定値（図示の形態では50%）より大きければ（ステップS2がNo）、 S/C を3（F1）とする（ステップS7）。そして、負荷が高くなった場合には改質ガスのリサイクルを行うと触媒での反応がうまく行かないでの、開閉弁V1を閉じる（ステップS8）。そして、弁V2、V3の開度を調節して、新たな S/C 比（=3）に対応する開度に、それ20ぞれ調節する（ステップS9、S10）。

【0030】

【発明の効果】本発明の作用効果を以下に例挙する。

（1） 低負荷領域においても、良好な発電効率を維持出来る。

（2） 高負荷領域においても、被毒を防止出来る。

（3） 高負荷領域においても、単位触媒当たりの原料ガスの量を増加させることができ、好適な反応を維持することが出来る。

【図面の簡単な説明】

30 【図1】本発明の実施の形態を示すブロック図。

【図2】図1の実施形態の制御フローチャートを示す図。

【図3】図1、2の実施形態の作用効果を説明するための特性図。

【図4】図1、2の実施形態と従来技術の発電効率とを比較して示す特性図。

【図5】従来の燃料電池装置の各種特性を示す特性図。

【符号の説明】

10・・・燃料電池装置

40 12、14、16、18、21、23、25、27、28・・・通路

A1・・・原料ガス

A2・・・水蒸気

A3・・・空気

V1、V2、V3・・・開閉弁

22・・・改質器

24・・・燃料電池本体（セル）

26・・・改質器バーナ

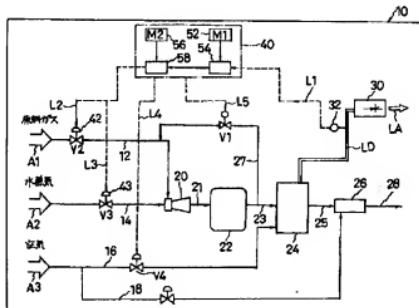
20・・・エジェクタ

50 LD、LA・・・電流ライン

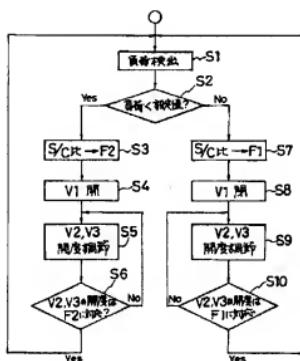
40...コントロールユニット
32...負荷センサ
52...第1のメモリ
54...第1の演算手段

5 6 . . . 第2のメモリ
5 8 . . . 弁開度決定手段
4 2, 4 3 . . . 開閉弁アクチュエータ
L 2, L 3, L 4, L 5 . . . 信号伝達ライン

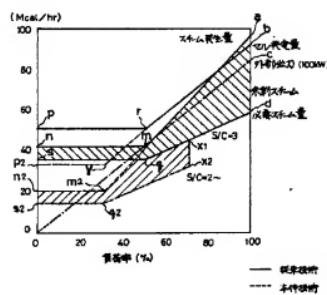
【 1】



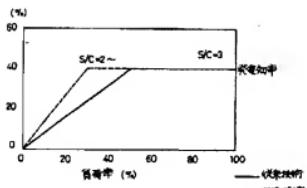
【图2】



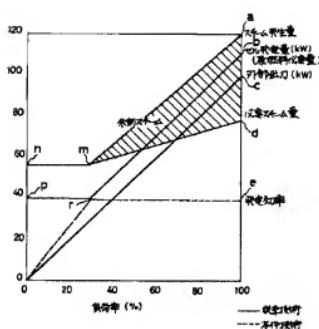
【图3】



【图 4】



【図5】



PATENT ABSTRACTS OF JAPAN

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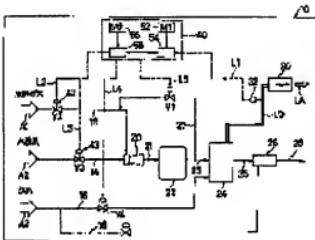
OTSUKA SHINJI

(54) FUEL CELL APPARATUS AND DRIVING METHOD THEREFOR

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a fuel cell apparatus and a driving method for the apparatus by which a catalyst is prevented from being poisoned and a reaction by the catalyst can be sufficiently carried out even in a high load region and a prescribed electricity generating efficiency can be maintained even in a low load region.

SOLUTION: A load of a fuel cell is measured by a load detecting means 32, a S/C (steam/carbon) ratio is determined by a S/C ratio determining means 40 based on the measured load, and the supply amounts of steam A2 and a raw material gas A1 to be supplied to a reformer of a fuel cell are controlled by supply amount controlling means 56, 58, V2, V3, 42, 43 based on the determined S/C ratio.



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CLAIMS**[Claim(s)]**

[Claim 1]A load detection process which measures load of a fuel cell, and a process of determining a steam carbon ratio based on measured load, An operating method of a fuel cell device including a control process made into a steam supplied to a reformer of a fuel cell, and a steam carbon ratio which controlled the amount of supply of material gas and was determined at said process.

[Claim 2]An operating method of a fuel cell device of claim 1 including a recycling process which branches reformed gas sent to a fuel cell from a reformer, and adds a part of reformed gas to material gas in front of refining.

[Claim 3]A load detection means to measure load of a fuel cell, and a steam carbon ratio determination means to determine a steam carbon ratio based on measured load, A fuel cell device including a steam supplied to a reformer of a fuel cell based on determination by a steam carbon ratio determination means, and an amount-of-supply regulation means which controls the amount of supply of material gas.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]**[0001]**

[Field of the Invention]This invention relates to a fuel cell device which generates material gas and a steam as a raw material, and an operating method for the same.

[0002]

[Description of the Prior Art]When operating a fuel cell, material gas and a steam are first supplied to a reformer, and after refining is carried out to the gas (hydrogen-rich gas: reformed gas) which includes a lot of hydrogen, they are supplied to a fuel cell body.

[0003]Here, about supplying material gas and a steam to a reformer at what kind of rate, it is expressed for the numerical value of a steam carbon ratio (mol ratio: describe it as the following "S/C ratio"). That is, if a S/C ratio increases and the rate of material gas increases relatively when there is much quantity of a steam, a S/C ratio will fall.

[0004]Since excessive quantity of heat will be taken out outside and it will be easy to use effectively separately if a S/C ratio is small, a thing small as much as possible is desirable. However, if a S/C ratio is small, it will be in what is called the state to which carbon deposited in the catalyst surface of the reformer, and the "state where the catalyst carried out poisoning", and the reaction promotion function of a catalyst will no longer be exhibited. And although the theoretical minimum of a S/C ratio is 2.0, it makes the S/C ratio about 3.0 by actual operation (fuel cell) in order to prevent poisoning of a catalyst.

[0005]

[Problem(s) to be Solved by the Invention]However, when a S/C ratio is operated about by 3.0, in the field where the load of a fuel cell is low, the problem that desired generation efficiency (apparent generation efficiency) is not acquired exists. The reason is explained with reference to drawing 5.

[0006]In drawing 5, the steam yield (steam yield) of a fuel cell device is ultimate-lines a-m-n, The production of electricity (kW: cell production of electricity : the initial complement of raw materials and mineral fuel proportionality) of a fuel cell is ultimate-lines b-r-p, and, as for the water vapor content (the amount of required steam) required for operation of the ultimate lines c-0 and a fuel cell device, ultimate-lines d-m-p and generation efficiency are shown for the external output (kW) by ultimate-lines e-r-0, and -- in the field where a load factor is larger than the part shown with the numerals r -- generation efficiency -- being fixed (the range of ultimate-lines e-r) -- in the field (the range of the ultimate lines r-0) where a load factor is small, generation efficiency is falling from the numerals r.

[0007]In the field (field of ultimate-lines m-n) where a load factor is small the numerals r and a load factor from the same part m, A water vapor content (the amount of required steam) required for operation indicates a fixed numerical value to be a load factor independently, and the production of electricity (cell production of electricity) of a fuel cell also serves as a fixed numerical value to the amount of required steam in the field of ultimate-lines r-p. And in the field where a load factor is

small (field of ultimate-lines $r-p$), in generating only the production of electricity proportional to an external output, it does not attain in the amount of steam which needs the amount of generating steam for refining. Therefore, the electric power for generating a steam required for refining of a fuel cell out of a cell production of electricity is used preferentially. Therefore, in the field (the range of the ultimate lines $r=0$) where a load factor is small, generation efficiency falls from the numerals r . [0008] This invention is proposed in view of the problem of the conventional technology mentioned above, and aims at offer of a fuel cell device which can hold predetermined generation efficiency also in a low loading field, and an operating method for the same.

[0009]

[Means for Solving the Problem] A load detection process in which an operating method of a fuel cell device of this invention measures load of a fuel cell. A control process made into a process of determining a steam carbon ratio (S/C ratio) based on measured load, a steam supplied to a reformer of a fuel cell, and a steam carbon ratio (S/C ratio) which controlled the amount of supply of material gas and was determined at said process is included.

[0010] A load detection means by which a fuel cell device of this invention measures load of a fuel cell. A steam carbon ratio determination means (S/C ratio determination means) to determine a steam carbon ratio (S/C ratio) based on measured load, A steam supplied to a reformer of a fuel cell based on determination by a steam carbon ratio determination means (S/C ratio determination means) and an amount-of-supply regulation means which controls the amount of supply of material gas are included.

[0011] According to this invention constituted by this appearance, in a field where load or a load factor is large, a load detection means detects that and a S/C ratio is determined as a big numerical value by a S/C ratio determination means. By this, the amount of hydrogen gas per unit catalyst is made proper, and a rate of material gas over a steam is made small, and poisoning is prevented. On the other hand, in a field where load or a load factor is small, a S/C ratio is determined as a small numerical value. Since the amount of required steam will decrease if a S/C ratio becomes small, as compared with a case where a S/C ratio is high, a steam yield exceeds the amount of required steam, and an export steam also generates a side with a low load factor. Therefore, even if it is a field where a load factor is low, the necessity of generating a steam by a production of electricity which should be taken out outside is lost. When putting in another way, as a result of a S/C ratio's becoming small and the amount of required steam decreasing, a critical point which an export steam generates, i.e., a critical point to which generation efficiency falls, shifted to a side with a small load factor.

[0012] Here, in an operating method of a fuel cell device of this invention, it is preferred to branch reformed gas sent to a fuel cell from a reformer, and to include a recycling process which adds a part of reformed gas to material gas in front of refining.

[0013] For example, by JP,7-215701.A, by recycling a part of reformed gas in a stage in front of refining, and decreasing the amount of carbon deposition to a catalyst, even if it falls a S/C ratio, art which can prevent poisoning is indicated.

[0014] A driving device of a fuel cell device of this invention branches from a reformed gas passage which sends reformed gas to a fuel cell from a reformer. It is preferred to include a reformed gas recycling passage which joins a material gas passage which supplies material gas in front of refining to a reformer, and a branch flow rate regulation means which is infix in this recycling passage and adjusts a branch flow rate from a reformed gas passage.

[0015] Although gas by which refining was carried out includes carbon dioxide (CO_2) and hydrogen (H_2), even if carbon dioxide (CO_2) does not carry out carbon deposition, works as a diluent of coal-for-coke-making-ized hydrogen concentration, therefore makes a S/C ratio low, there is little fear of poisoning.

[0016]

[Embodiment of the Invention] Hereafter, one embodiment of this invention is described with reference to drawing 1–4 of an accompanying drawing. In a figure, the same numerals are given to the same member, and duplication explanation is omitted. In drawing 1, the fuel cell device of this invention shows the whole with the numerals 10.

[0017] Material gas (arrow A1) and a steam (arrow A2) are supplied to the fuel cell device 10 via the passages 12 and 14, respectively. Here, the amount of supply of the material gas A1 and the steam A2 or the rate of a delivery late (S/C ratio) is adjusted by controlling the opening and closing valve V2 and the opening of V3 (a control mode is mentioned later), respectively. The air shown in the fuel cell device 10 by arrow A3 is also supplied, and this air A3 is supplied to the air pole of the fuel cell body (cell) 24 via the passage 16, and it is supplied to a reformer burner via the passage 18.

[0018] The material gas A1 and the steam A2 which were supplied via the passages 12 and 14 join with the ejector 20, and are supplied to the reformer 22 via the passage 21. Fuel gas CH_4 and steam H_2O supplied to the reformer 22 becomes mixed gas (hydeogen-rich gas: reformed gas) with carbon dioxide CO_2 which included many hydrogen gas H_2 by the reaction in the reformer 22. And reformed gas is supplied to the fuel electrode of the fuel cell body (cell) 24 via the passage 23.

[0019] From the passage 23, the passage 27 which infixes the opening and closing valve V1 has branched, and this branch passage 27 joins the supply path 12 of the material gas A1 (with upstream of the ejector 20).

[0020] The reformed gas discharged from the fuel cell body (cell) 24 is supplied to the ***** burner 26 via the passage 25, and is discharged from the flueway 28. The direct current generated in the cell 24 is sent to the inverter 30 via line LD shown in the 2 main lines in drawing 1, is changed into exchange in the inverter 30, and is supplied to load (arrow LA).

[0021] The load sensor 32 is infix in line LD, and the measurement result is sent to the control unit 40 via the signal transduction line L1. This control unit 40 is a member applicable to a steam carbon ratio determination means. The 1st memory 52 by which the relation of the load and the S/C ratio which were detected by the sensor 32 was recorded on the control unit 40 with the gestalt of expression, a characteristic figure, or a table, The 1st calculating means 54 that calculates a S/C ratio with the memory concerned and the output signal from the sensor 32, The relation between a S/C ratio, and the opening and closing valve V2 and the valve opening of V3 is provided with a valve opening determination means 58 to determine the opening and closing valve V2 and the valve opening of V3 from the 2nd memory 56 recorded with the gestalt of expression, a characteristic figure, or a table, and the output and the 2nd memory of the 1st calculating means. And the output signal of this valve opening determination means 58, The actuator 42 of the opening and closing valve V2 which controls the amount of supply of the material gas A1 via the signal transduction line L2 and L3, respectively, It is sent out to the actuator 43 of the opening and closing valve V3 which controls the amount of supply of the steam A2, and cheats to the opening corresponding to this valve V2 and the S/C ratio which had the valve opening of V3 determined.

[0022] The valve V2 and the actuator 42 correspond to the amount-of-supply regulation means which controls the amount of supply of material gas, and the valve V3 and the actuator 43 correspond to the amount-of-supply regulation means which controls the amount of supply of a steam. And a signal transduction line for the numerals L4 to control the air supply to the air pole of the cell 24 and the numerals L5 are the signal transduction lines for controlling the flow of the reformed gas for recycling which flows through the branch passage 27.

[0023] Next, also with reference to drawing 2 and drawing 3, an operation of the embodiment shown by drawing 1 is explained. Here, a S/C ratio shall be determined as two kinds of numerical F1 (drawing 3 3), and either of F2 (drawing 3 2) corresponding to load.

[0024] First, the control in the case of load falling and a S/C ratio falling to 2 from 3 is explained. The load sensor 32 detects the load of the fuel cell device 10 (Step S1). And it is judged whether the detected load (the example of a graphic display load factor) was less than the predetermined

value (numerical value which is case-by-case and becomes settled) (Step S2). Here, let 50% of the load factor corresponding to the part shown with the numerals r, m, and q in drawing 3, i.e., a load factor, be said predetermined value in the embodiment of a graphic display.

[0025] If the detected load is less than a predetermined value (Step S2 is Yes), a S/C (it was 3 till then) ratio will be determined as 2 by the 1st memory 52 and 1st calculating means 54 (Step S3). In the embodiment of a graphic display, in order to prevent poisoning of a catalyst when a load factor is low (when Step S2 is Yes), the opening and closing valve V1 is opened wide, and reformed gas is recycled (step S4).

[0026] If a S/C ratio is determined in Step S3 (S/C ratio =2), the opening and closing valve V2 and the opening of V3 will be adjusted so that it may be in agreement with the S/C ratio (=2) as which the ratio of the amount of supply of the material gas A1 and the steam A2 was determined. The valve V2 corresponding by the 1st output, 2nd memory 56, and valve opening determination means 58 of the calculating means 54 and the opening of V3 can specifically be found, and it is sent to the actuators 42 and 43 of each valve via the line L2 and L3 as a control signal (Step S5, Step S6).

[0027] Thus, the effect of having changed the S/C ratio to 2 from 3 is explained mainly with reference to drawing 3. In drawing 3, the part shown by the agreement x1 shows the point which shifts to S/C ratio =2 from S/C ratio =3. S/C ratio = before the surplus of steam is lost in the state of three, it shifts to the state of S/C ratio =2. When agreement x2 shifts to S/C ratio =2 from S/C ratio =3 in the part shown by the agreement x1, it is a part which shows the amount of required steam in S/C ratio =2. It is a point judged that the surplus or margin of steam of the part shown by the agreements m2 and q2 is lost also in the state of S/C ratio =2. However, the judgment method of the margin of steam changes with each fuel cells. "m2-q2" becomes a margin. The agreement Y means the part where said margin (m2-q2) serves as a lower limit, or the part judged that said margin is lost. And it is controlled by the field where load is smaller than the part shown by the agreement Y so that the amount of export steams (or a margin: m2-q2) becomes fixed. The agreement x1 mentioned above, x2, m2, and q2 grade change with characteristics of each fuel cell, and need to calculate a mass balance and heat balance with each fuel cell. In drawing 3, as a result of a S/C ratio's changing from 3 to 2 in the part of 50% of a load factor, the ultimate lines of the amount of required steam change from d-q-s to d-x1-x2-q2-s2. In connection with this, a steam yield changes from the ultimate lines shown by a-r-p to the ultimate lines shown by a-m2-n2, and a production of electricity also changes from ultimate-lines b-r-p to ultimate-lines b-y-p2.

[0028] When a S/C ratio is 3, generation efficiency gets worse from about 50% of a load factor, as drawing 4 also shows it. On the other hand, as a result of setting a S/C ratio to 2, the load factor corresponding to the numerals y, m2, and q2, about 30% of a load factor, and until predetermined efficiency (about 40%) can be maintained.

[0029] On the other hand, when load increases and a S/C ratio increases from 2 to 3, the same control as this and an outline is performed. That is, S/C will be set to 3 (F1) if load (load factor) is larger than a predetermined value (the gestalt of a graphic display 50%) (Step S2 is No) (Step S7). And since the reaction in a catalyst will not go well if reformed gas is recycled when load becomes high, the opening and closing valve V1 is closed (Step S8). And the valve V2 and the opening of V3 are adjusted and it adjusts to the opening corresponding to a new S/C ratio (=3), respectively (step S9, S10).

[0030]

[Effect of the Invention] The operation effects of this invention are enumerated below.

- (1) Also in a low loading field, good generation efficiency is maintainable.
- (2) Poisoning can be prevented also in a high load range.
- (3) Also in a high load range, quantity of the material gas per unit catalyst is not made to increase, and a suitable reaction can be maintained.

[Translation done.]

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TECHNICAL FIELD

[Field of the Invention] This invention relates to a fuel cell device which generates material gas and a steam as a raw material, and an operating method for the same.

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PRIOR ART

[Description of the Prior Art] When operating a fuel cell, material gas and a steam are first supplied to a reformer, and after refining is carried out to the gas (hydrogen-rich gas: reformed gas) which includes a lot of hydrogen, they are supplied to a fuel cell body.

[0003]Here, about supplying material gas and a steam to a reformer at what kind of rate, it is expressed for the numerical value of a steam carbon ratio (mol ratio: describe it as the following "S/C ratio"). That is, if a S/C ratio increases and the rate of material gas increases relatively when there is much quantity of a steam, a S/C ratio will fall.

[0004]Since excessive quantity of heat will be taken out outside and it will be easy to use effectively separately if a S/C ratio is small, a thing small as much as possible is desirable. However, if a S/C ratio is small, it will be in what is called the state to which carbon deposited in the catalyst surface of the reformer, and the "state where the catalyst carried out poisoning", and the reaction promotion function of a catalyst will no longer be exhibited. And although the theoretical minimum of a S/C ratio is 2.0, it makes the S/C ratio about 3.0 by actual operation (fuel cell) in order to prevent poisoning of a catalyst.

0005

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EFFECT OF THE INVENTION

[Effect of the Invention]The operation effects of this invention are enumerated below.

- (1) Also in a low loading field, good generation efficiency is maintainable.
- (2) Poisoning can be prevented also in a high load range.
- (3) Also in a high load range, quantity of the material gas per unit catalyst is not made to increase, and a suitable reaction can be maintained.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention]However, when a S/C ratio is operated about by 3.0, in the field where the load of a fuel cell is low, the problem that desired generation efficiency (apparent generation efficiency) is not acquired exists. The reason is explained with reference to drawing 5.

[0006]In drawing 5, the steam yield (steam yield) of a fuel cell device is ultimate-lines $a=m-n$. The production of electricity (kW: cell production of electricity : the initial complement of raw materials and mineral fuel proportionality) of a fuel cell is ultimate-lines $b=r-p$, and, as for the water vapor content (the amount of required steam) required for operation of the ultimate lines $c=0$ and a fuel cell device, ultimate-lines $d=m-p$ and generation efficiency are shown for the external output (kW) by ultimate-lines $e=r=0$, and -- in the field where a load factor is larger than the part shown with the numerals r -- generation efficiency -- being fixed (the range of ultimate-lines $e=r$) -- in the field (the range of the ultimate lines $r=0$) where a load factor is small, generation efficiency is falling from the numerals r .

[0007]In the field (field of ultimate-lines $m-n$) where a load factor is small the numerals r and a load factor from the same part m , A water vapor content (the amount of required steam) required for operation indicates a fixed numerical value to be a load factor independently, and the production of electricity (cell production of electricity) of a fuel cell also serves as a fixed numerical value to the amount of required steam in the field of ultimate-lines $r=p$. And in the field where a load factor is small (field of ultimate-lines $r=p$), in generating only the production of electricity proportional to an external output, it does not attain in the amount of steam which needs the amount of generating steam for refining. Therefore, the electric power for generating a steam required for refining of a fuel cell out of a cell production of electricity is used preferentially. Therefore, in the field (the range of the ultimate lines $r=0$) where a load factor is small, generation efficiency falls from the numerals r .

[0008]This invention is proposed in view of the problem of the conventional technology mentioned above, and aims at offer of a fuel cell device which can hold predetermined generation efficiency also in a low loading field, and an operating method for the same.

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MEANS

[Means for Solving the Problem]A load detection process in which an operating method of a fuel cell device of this invention measures load of a fuel cell, A control process made into a process of determining a steam carbon ratio (S/C ratio) based on measured load, a steam supplied to a reformer of a fuel cell, and a steam carbon ratio (S/C ratio) which controlled the amount of supply of material gas and was determined at said process is included.

[0010]A load detection means by which a fuel cell device of this invention measures load of a fuel cell and a steam carbon ratio determination means to determine a steam carbon ratio (S/C ratio) based on measured load

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1]The block diagram showing an embodiment of the invention.

[Drawing 2]The figure showing the control flow chart of the embodiment of drawing 1.

[Drawing 3]The characteristic figure for explaining the operation effect of drawing 1 and the embodiment of 2.

[Drawing 4]Drawing 1, the characteristic figure comparing and showing the embodiment of 2, and the generation efficiency of conventional technology.

[Drawing 5]The characteristic figure showing the various characteristics of the conventional fuel cell device.

[Description of Notations]

10 ... Fuel cell device

12, 14, 16, 18, 21, 23, 25, 27, 28 ... Passage

A1 ... Material gas

A2 ... Steam

A3 ... Air

V1, V2, V3 ... Opening and closing valve

22 ... Reformer

24 ... Fuel cell body (cell)

26 ... Reformer burner

20 ... Ejector

LD, LA ... Current lines

40 ... Control unit

32 ... Load sensor

52 ... The 1st memory

54 ... The 1st calculating means

56 ... The 2nd memory

58 ... Valve opening determination means

42, 43 ... Opening and closing valve actuator

L2, L3, L4, L5 ... Signal transduction line

[Translation done.]